Science of Diversity

Why we didn't get diversity right the first time

Norman L. Johnson

Theoretical Division
Los Alamos National Laboratory

NORMAN@LANL.GOV
http:// ishi.lanl.gov

Presentation to Corporate Diversity Team
Sandia National Laboratory, 14 NOV 2002

Take aways…

- Diversity has different roles at “stages” of development. Conflict and performance can be better managed by recognizing the “stage”.
- Our modern world is challenging us by
  - Faster change
  - Greater uncertainty
  - More “mixing”
- Understanding the strengths and weaknesses of collectives is essential
- Our social behavior is a complicating factor - but need not be mysterious and unmanageable

Diversity - As the morally right thing to do

- My view, for a long time, was that supporting diversity was is morally the right thing to do…

  And I naively assumed it was the same as affirmative action.

  It is difficult to think back to those times, but I believe the problem was that I viewed the world as a competitive.

- Where did that come from?

  I think it's because the idea of natural selection - popularized as "survival of the fittest" – dominates our view of the world.

I was asked to “Make it Personal”

- **Why am I here today?**
- **What made me become an advocate for Diversity? Especially since I’m:**

White - Northern European
Male
Q- Cleared
Ph.D.
US born
Exit-seating capable

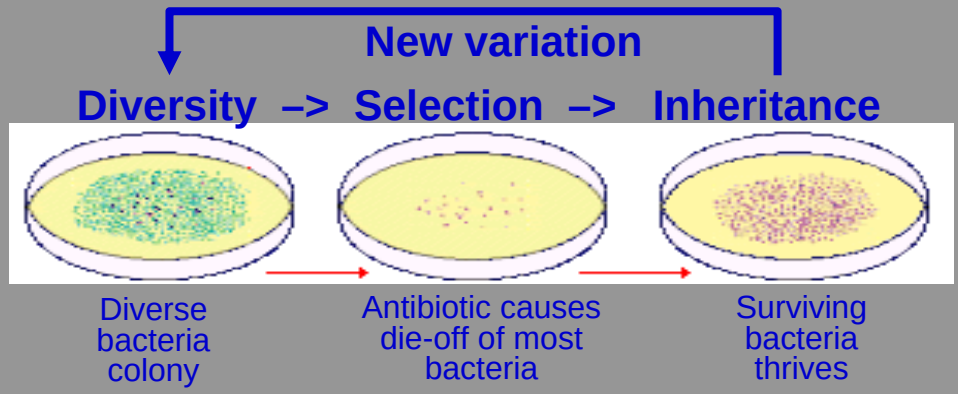
Diversity and Natural Selection

Higher performance results as a consequence of selection from a diverse population.

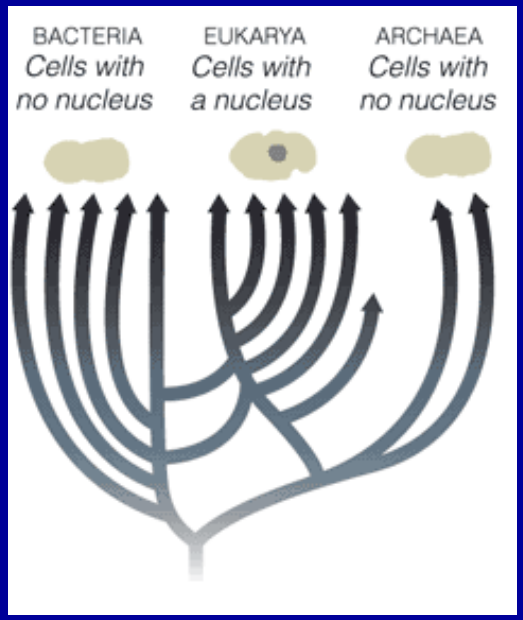
Diversity lowers the global performance:

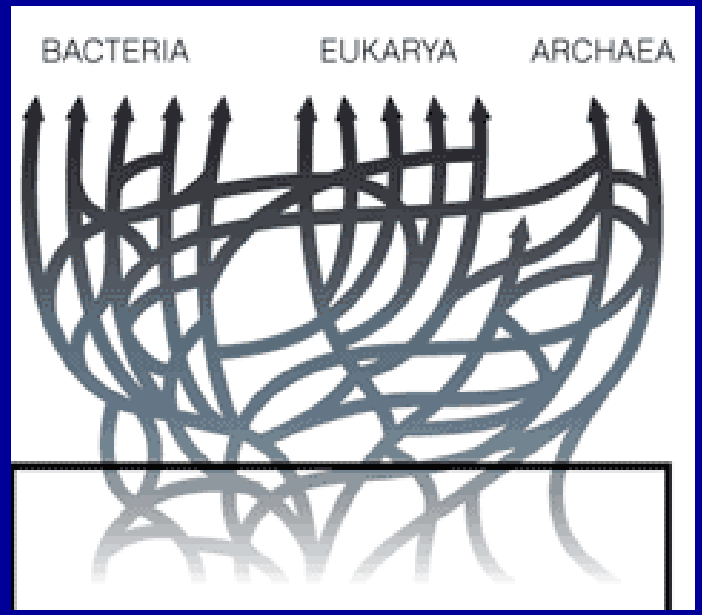
Lower performance of "unfit" individuals leads to lower "average" population performance

Engine of Natural Selection



What are the “experts” saying?





A crisis being caused by timings of evolution based on DNA

- *Lamarckian Evolution (experience is heritable)*
- *What happens when the world gets “complex”?*

Examples of the Complexity Barrier

- **When many genotypes lead to one phenotype, traits become independent of selection** (Shipman)
- **When complexity of the global problem increases, selection in genetic algorithms do not result in improvement** (Hart)
- **Strong artificial selection on bacteria populations fail sometimes to pass on optimal performance** (Swenson & Wilson)

- **Plague of false positives in problem solving**
- **Modern experts only give answers, not rules**

Y2K was?

- 1. Was one of the greatest wastes of money/energy of all times.
- 2. Was taken seriously, and prevented.

How well do we understand?

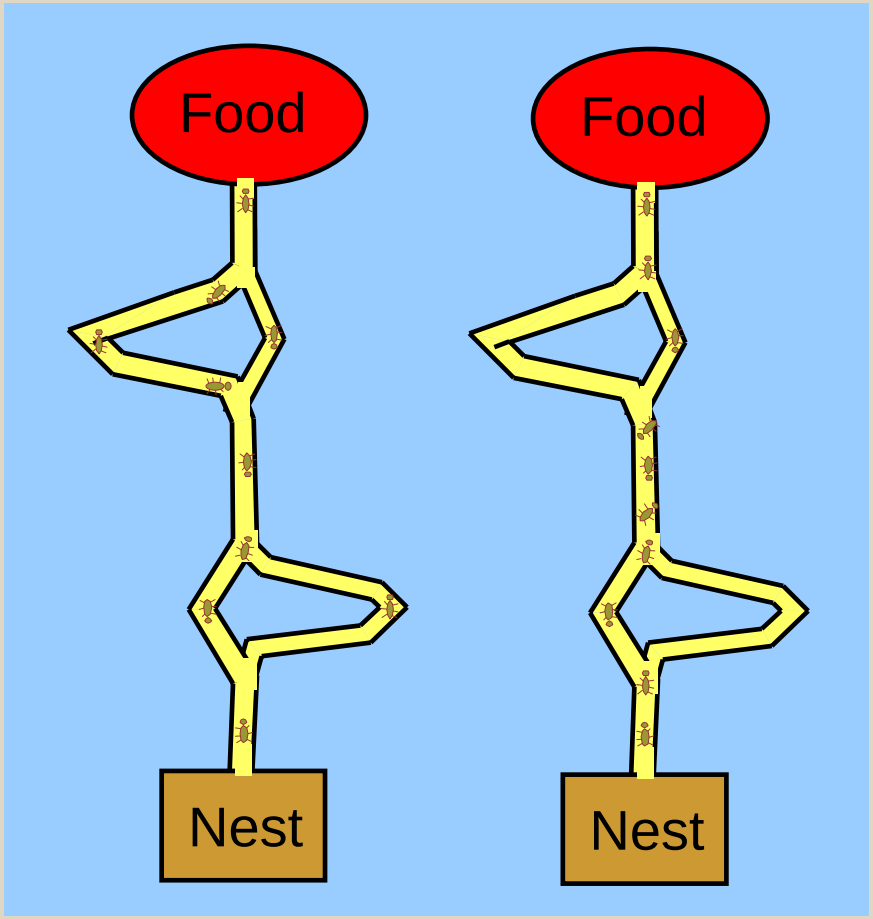
- The Real Significance of Y2K

To what degree can “society” fail and society still continue?

It was not what did or didn’t happen during Y2K that was significant; it was that we didn’t know what would happen if something did go wrong. We couldn’t answer this question when we needed to.

This is a major admission of ignorance about our understanding of how decentralized systems really work and survive, despite their extreme importance.

Dumb Collectives Solving “HARD” problems

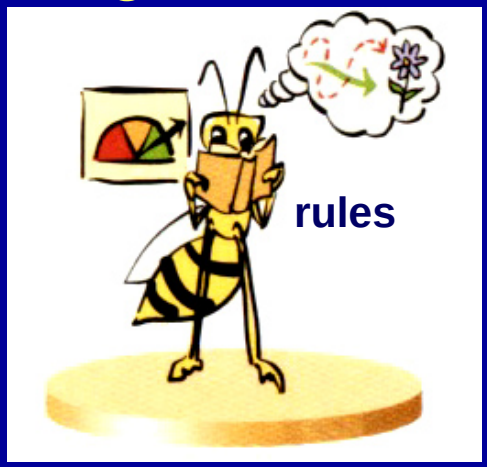


(Goss, et al. 1989)

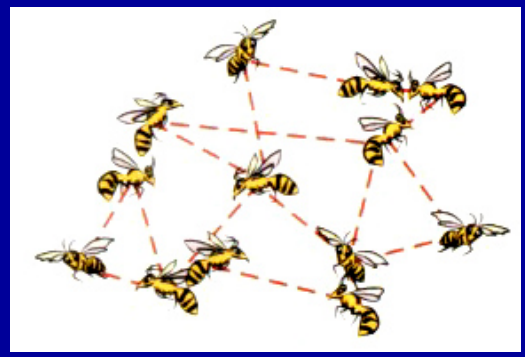
- **Individuals are “dumb,” chaotic, no global perspective**
- **No leaders or central coordination**
- **Only works for groups of diverse ants** (and slime molds!!)

Self-Organizing Adaptive Systems

Agent



Interaction



Emergent properties

"Solutions" arise from the dynamics from a diversity of potential solutions.
Decentralized, robust, adaptable, fault-tolerant, scalable, ...

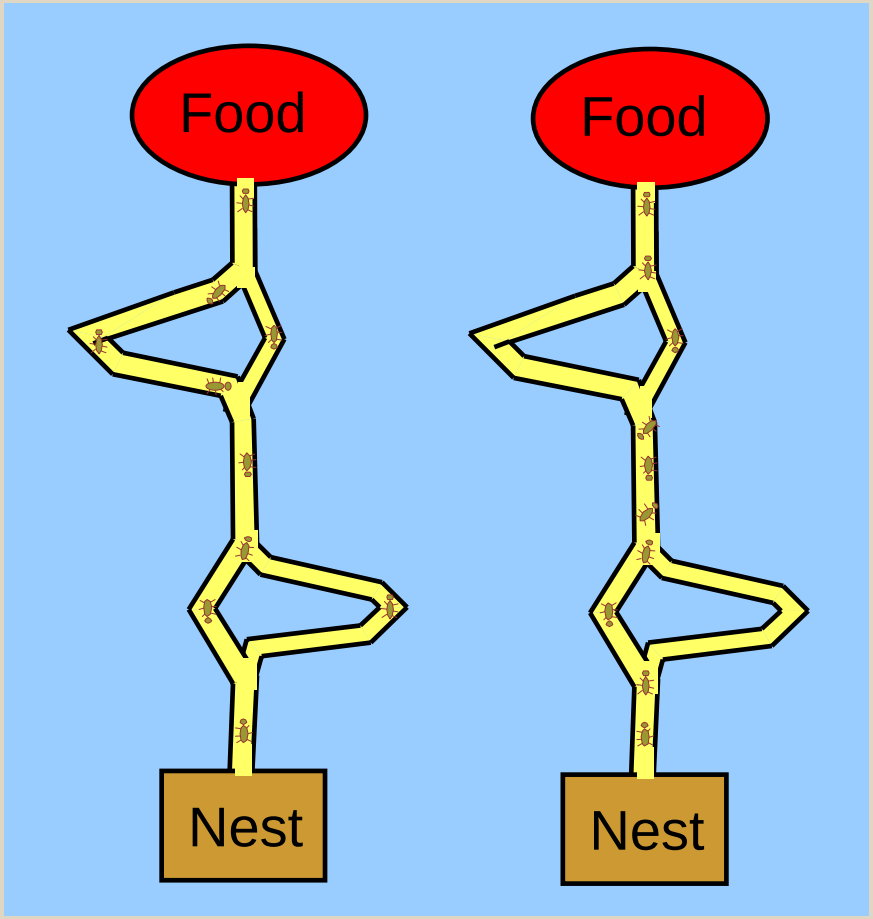
Fundamental concepts

Chaotic behavior *or* non-linear response

Structure in chaos

Emergent properties

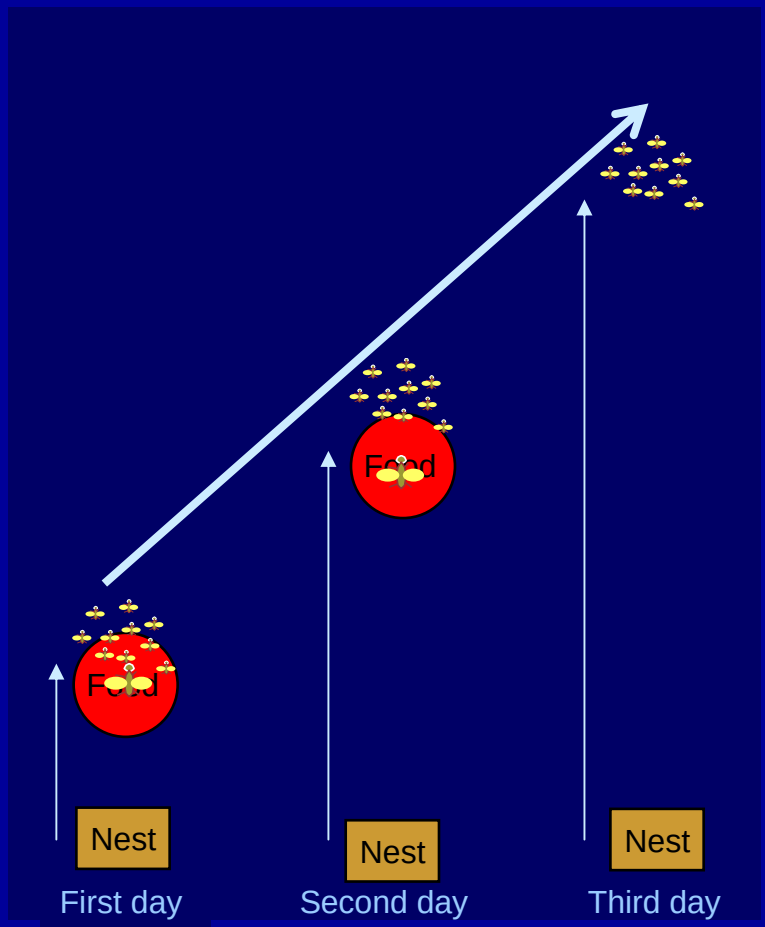
Dumb Collectives Solving “HARD” problems



(Goss, et al. 1989)

- **Individuals are “dumb,” chaotic, no global perspective**
- **No leaders or central coordination**
- **Only works for groups of diverse ants** (and slime molds!!)

Don’t underestimate collectives Researching Bee Talk



Where is the prediction taking place?

Where is memory located?

- **Bee memory - 1 week**
- **Bee life - 6 week.**
- **Hive memory - 12 weeks.**

Why are social insects so disturbing?

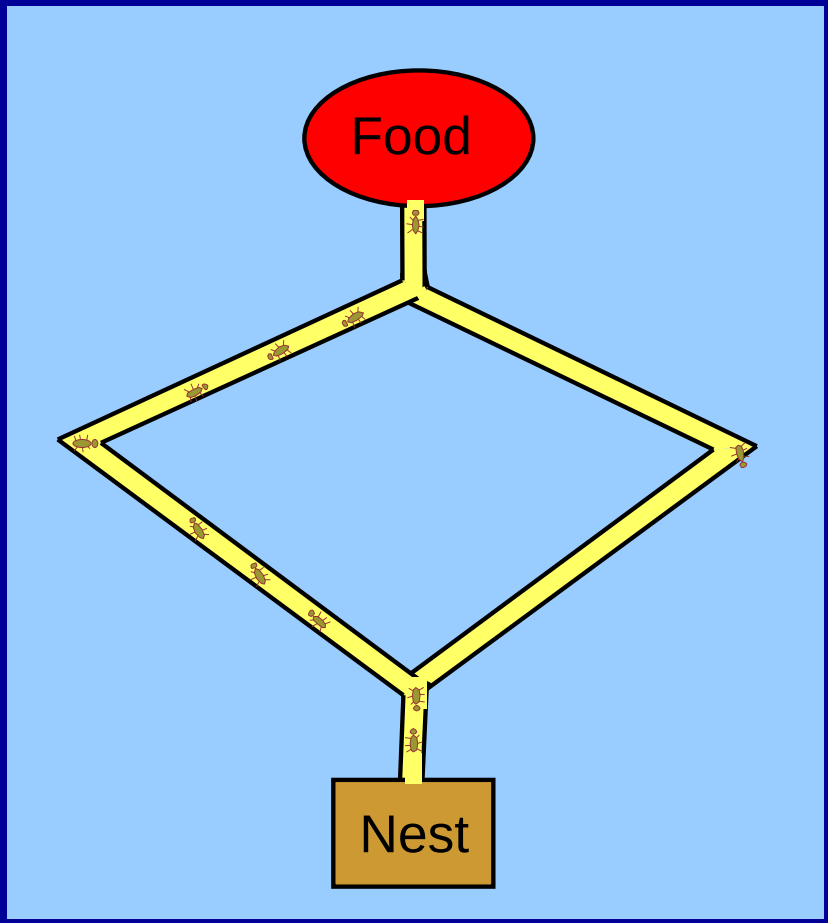
- **All hive functions are emergent properties (just like the human brain)**

Why aren’t we as impressed with human collectives?

- **We are part of the system. And because we believe that the “system” is doing all the work.**

The Problem with Collective Effects

Ants foraging for food chose one path out of two equidistant paths.



(Deneubourg et al. 1990)

Cooperation leads to exclusive behavior in stable environments

Non-linear or Chaotic behavior: Positive reinforcements can amplify random weak signals >> global chaos.

A Self-Organizing Simulation

Using StarLogo

Simple Consumer Model

- **Collective information**
  - Evaporation
  - Diffusion
- **Agent internal state:**
  - Current direction
  - Have product?
- **Three rules of action:**
  - Carry product
  - Drop product
  - Search for product

Nest

Food supply

Consumers:

- **Successful buyer**
- **Returning home**
- **Searching for a store**

store

Why study a simple model?

Resemble humans systems:

Individuals within a collective

Highly decentralized

"Socially" driven

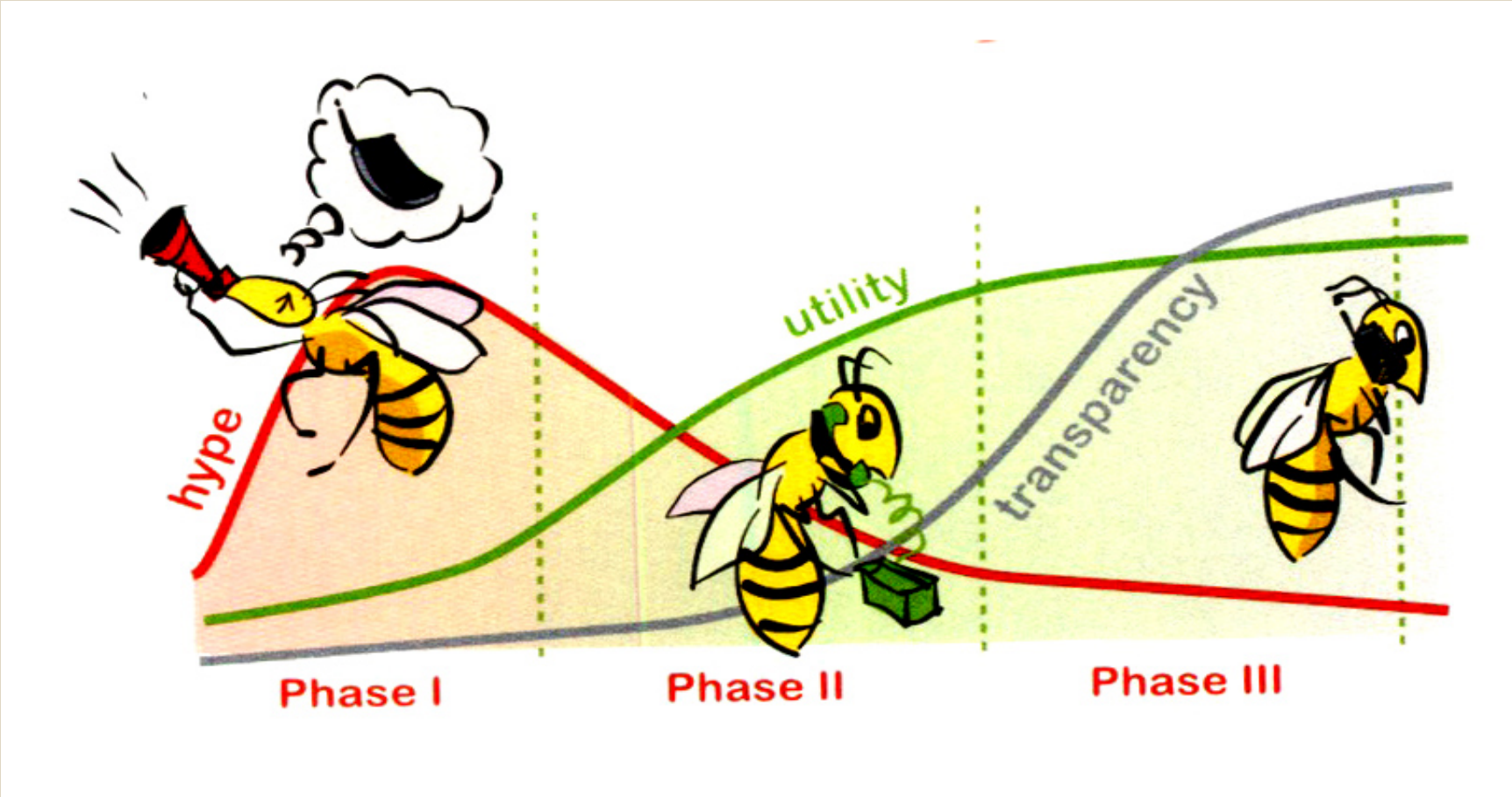
Extremely adaptive

You can duplicate the results with social insects

A single stationary source of infinite supply

Almost everything has cycles or stages of development

Normal Cycle of Technology Development

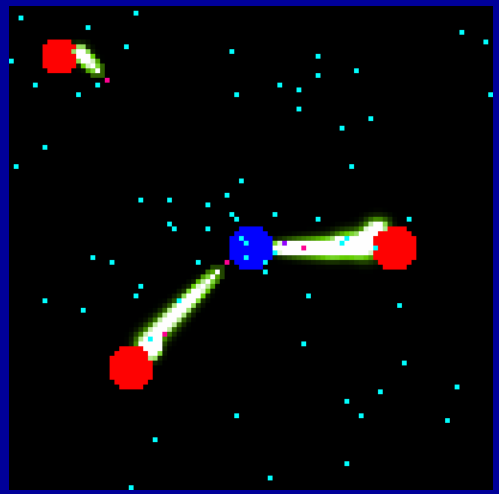


And you act differently at different stages

Diversity in the Stages

Formative

Forming definition

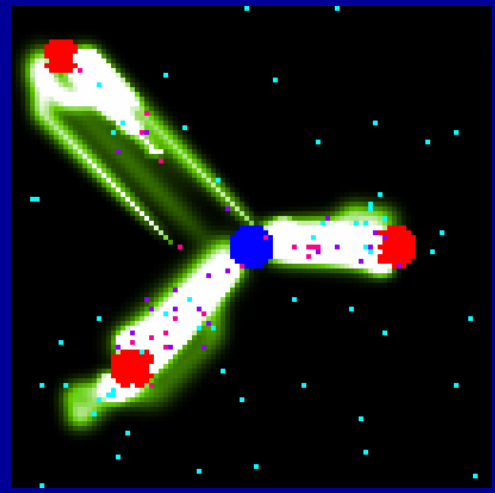


Diversity is consumed by selection

Lowers performance

Co-Operational

Synergy of Individuals

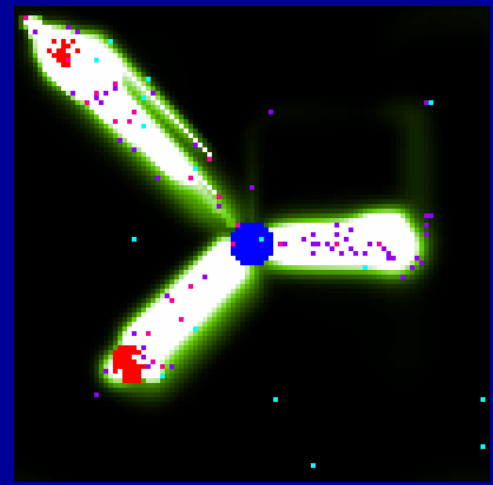


Diversity is essential for performance.

Reduction in diversity lowers performance

Condensed

System optimization

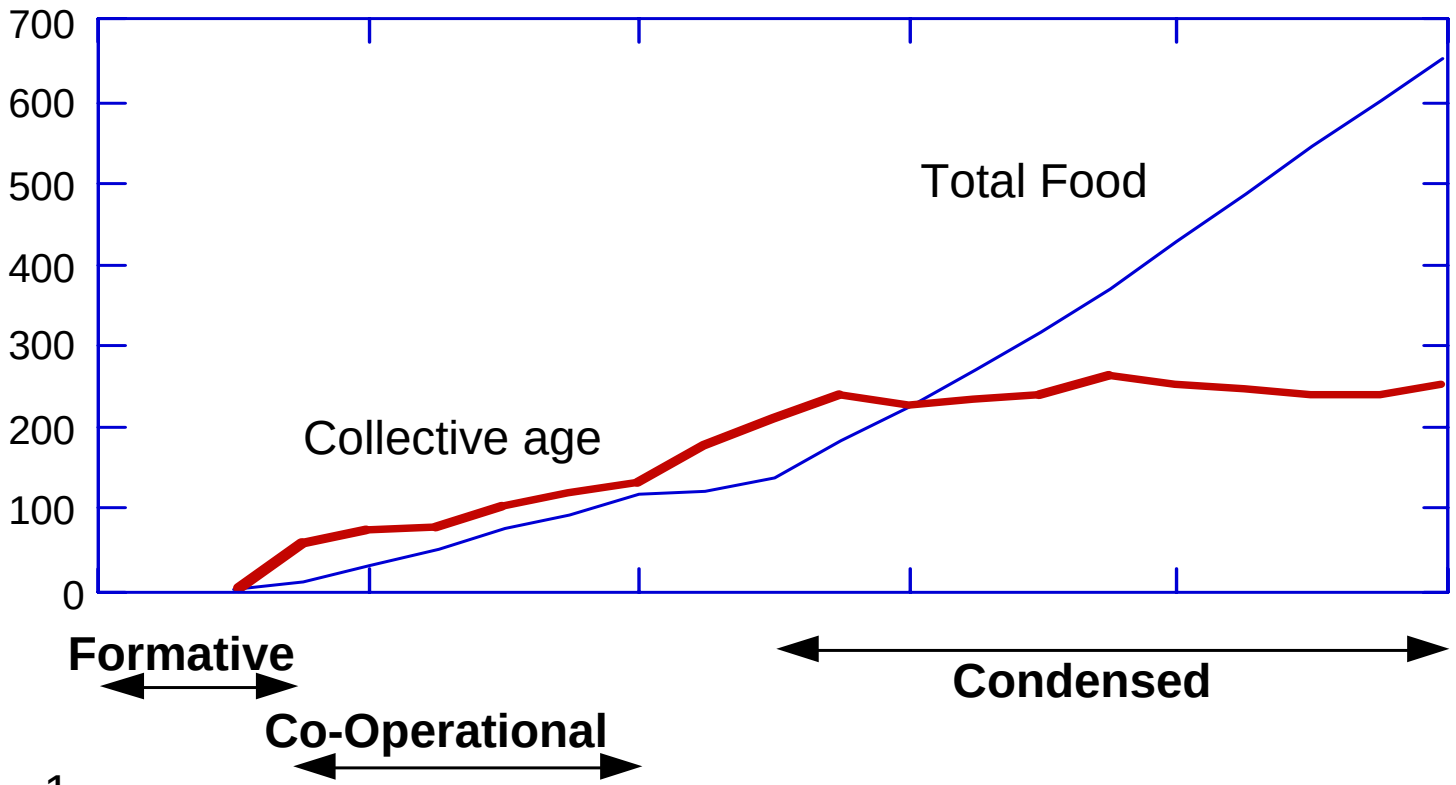


Little diversity.

Diversity outside the “norm” may not thrive

Three stages for a stable environment

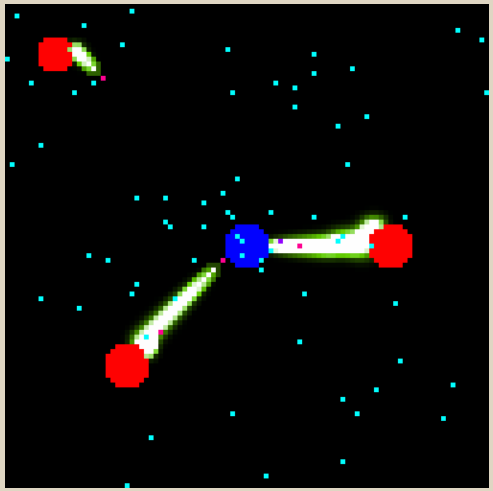
Total Production versus time



Stages of Development

Formative

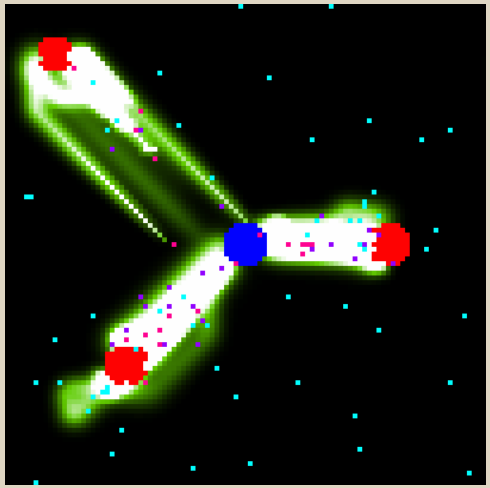
Forming definition



- Locally chaotic (agent's path)
- Globally chaotic (productivity)
- Low and evolving "structure" – no collective network
- Performance due to uncorrelated diverse contributions
- High diversity

Co-Operational

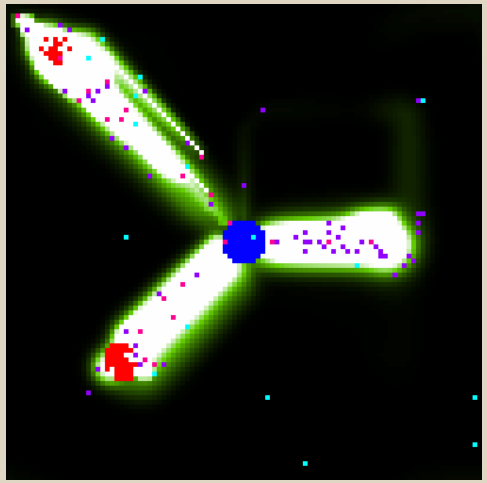
Synergy of Individuals



- Locally chaotic
- Globally predictable
- Adaptive "structure" – robust collective network
- Performance from combination of diverse contributions
- High diversity

Condensed

System optimization



- Locally predictable
- Globally predictable
- Unchanging "structure" – dominant collective network
- Performance due to optimized population (low diversity)
- Low diversity

Diversity and Development

Development of Exclusive Cooperation

Loss of global robustness

System failure

Stable environment –> Flexible interactions become fixed

Diversity leads to Synergy and Collective Benefits

Individual and global improvement without selection

System-wide robustness

Higher individual performance –> complexity barrier –> higher diversity

Natural Selection

Diversity leads to “low” global performance

One Business Argument

Informal learning is the source of up to 70% of our work knowledge

Two year, $1.6 million DOL study of Motorola, Boeing, Ford, etc.

Why are centralized, formal sources lacking?

$100-120 billion a year is spent on formal training programs,
Yet in complex situations, how is the “best training” determined?

Why are these informal sources helpful?

Individual problem solving in a common environment.
Diversity gives unique perspectives (not about optimal performance).
Individuals contribute to something much greater than they perceive.

How do we tap the huge collective resources?

Investment in enabling Diversity activates informal learning.
Individuals expression, Listen to others, Mixing communities.

Explaining the miracle of US worker productivity…

Your Work Knowledge and Risks?

1. *I work by general rules/policies that apply for all times - risk is low.*

2. *Each situation requires separate approach or analysis - risk is present.*

3. *Rules are flexible, but there is little risk*.

4. I follow perceived rules - risk seems high.

Job Knowledge and Environment

- *Each situation requires separate analysis ->*
  - Formative stage
  - High risk, individually focused, but with growing structure.
  - Diversity, but in conflict.
- *Rules adapt constantly to the changing times ->*
  - Co-Operational stage
  - Locally chaotic, but globally robust. Lower risk.
  - Interconnectivity and shared information important.
  - Learning is from many diverse sources.
- *I work by general rules/policies ->*
  - Condensed stage
  - A innovative idea is viewed as a error (follow perceived rules!).
  - Optimized, efficient in a stable environment, but fragile.
  - Some diversity but it doesn’t change.

The Bad Side of the “Herd” Effect

Add some food to an existing solution

The prior “optimized” solution prevents the system from further optimization

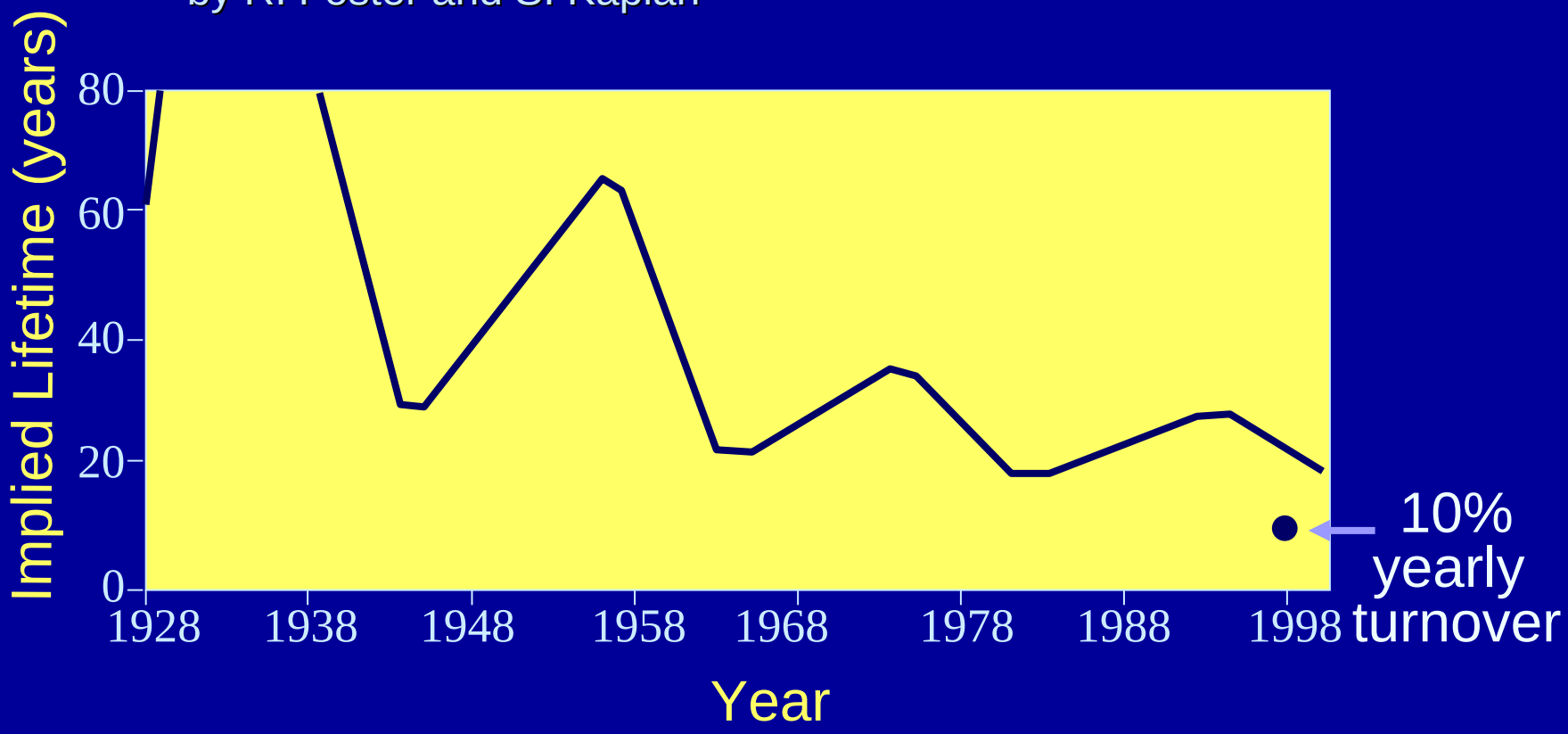
Worse for systems with that internalize optimal solutions.

Why worry about change?

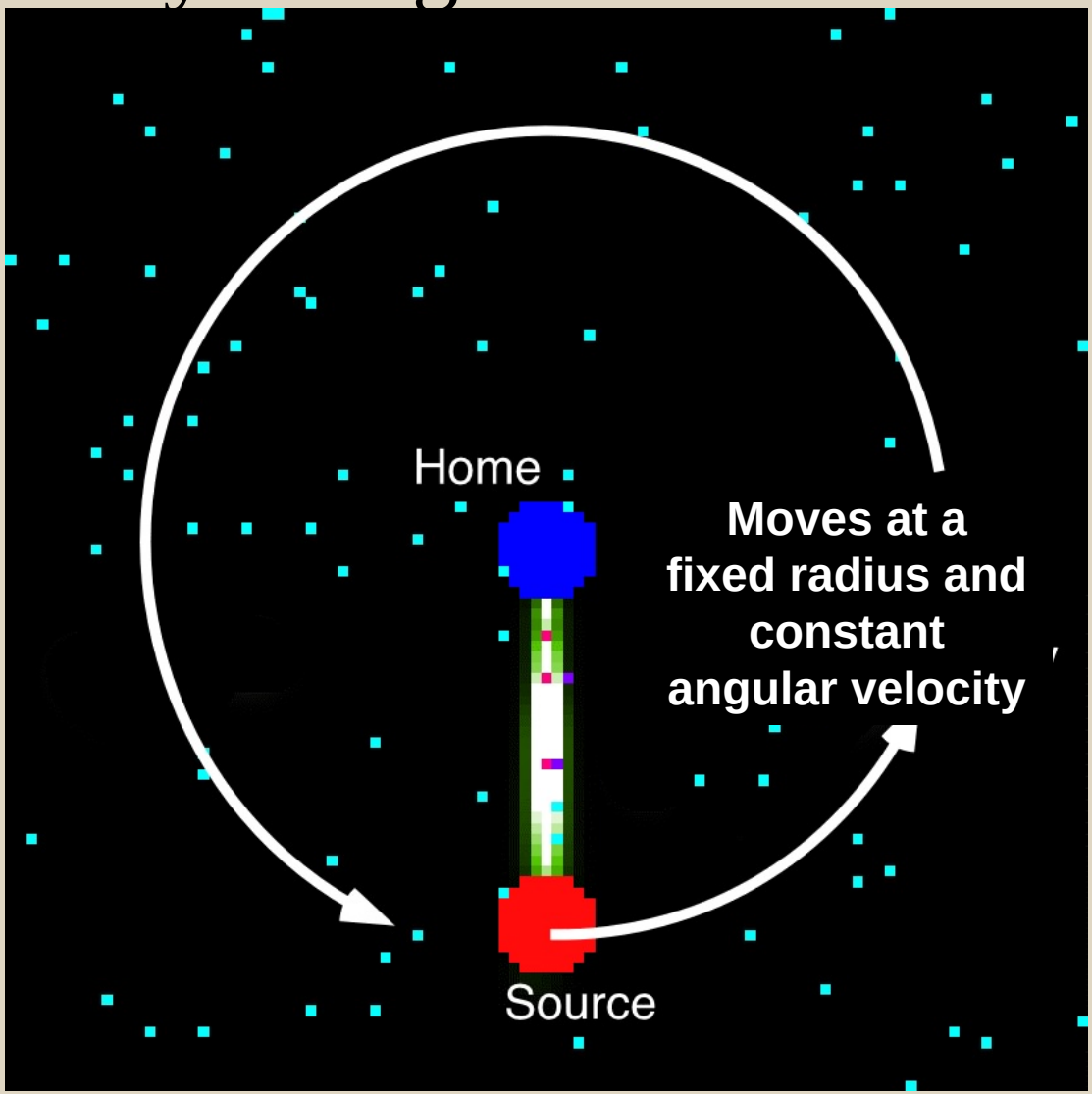
Average Lifetime of S&P 500 Companies

From ***Creative Destruction***

by R. Foster and S. Kaplan



Try to quantify change and the herd effect



Slowly changing environment

Productivity is only slightly less than an unchanging source

Herd effect allows for quick utilization of new resource location

Innovators become important (again) by sustaining optimal performance of the collective

Faster by 1/3

Boom and bust cycle

Instabilities lead to reversion to prior developmental stages.

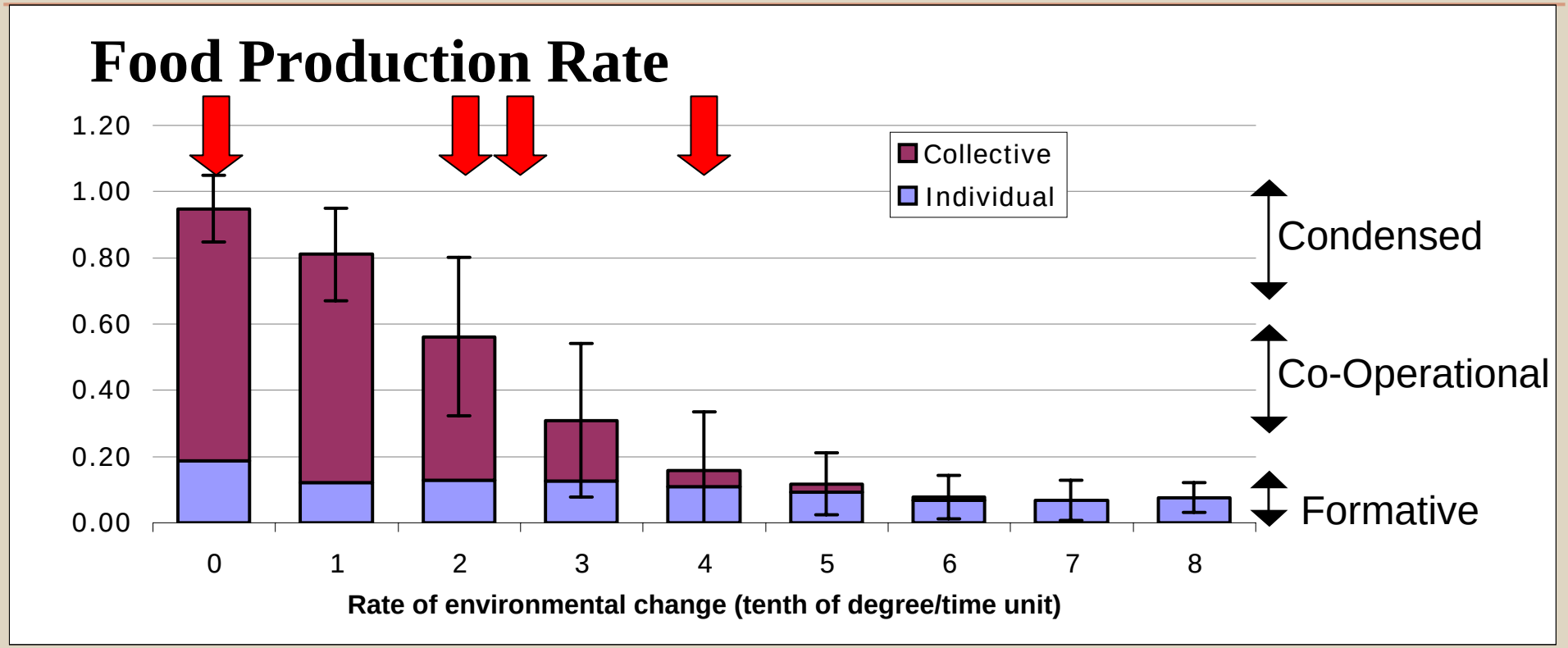
Equal importance of herd effect and innovators

Rapidly changing environment

Almost all productivity is from innovators

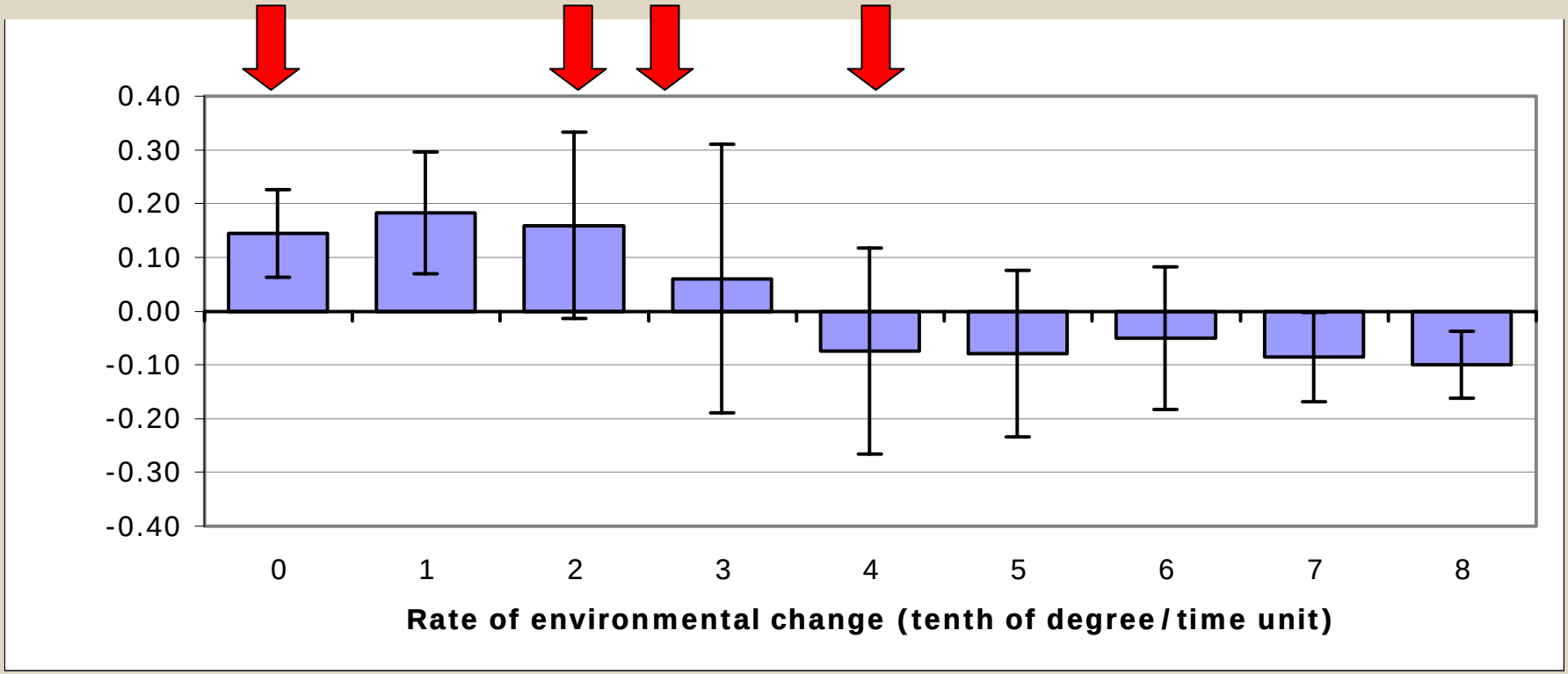
The highly productive Condensed stage is never realized

The herd effect can actually degrade the performance by tying up resources


Food Production Rate
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Collective
Individual
Condensed
Co-Operational
Formative
0
1
2
3
4
5
6
7
8
Rate of environmental change (tenth of degree/time unit)

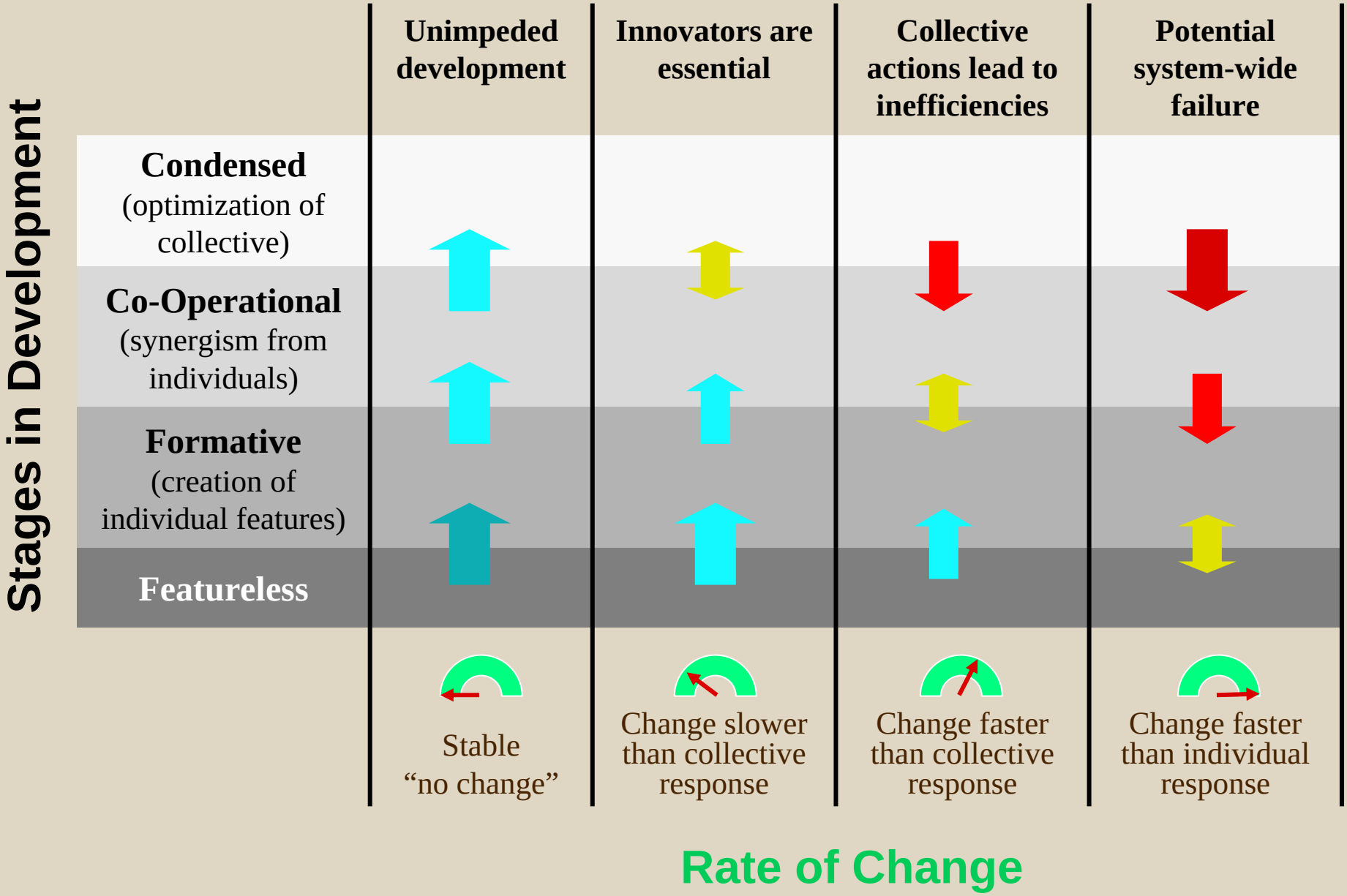
0 2 2.5 4

Collective efficacy (structural efficiency) vs. Diversity



0 2 2.5 4

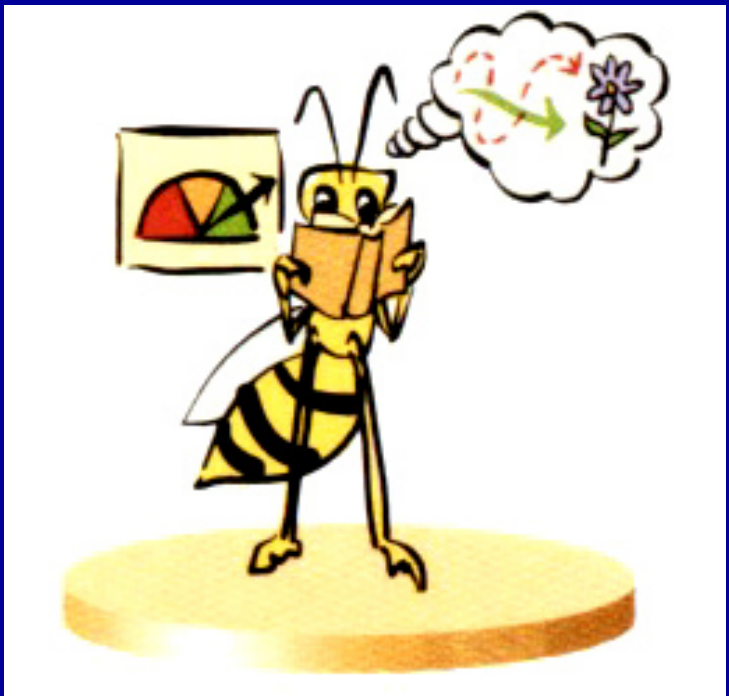
Collective Response to Rates of Change



Apply to “Our” system

Survival is all about understanding change and responding appropriately.

Survival is becoming all about managing the context of decision making.



Context is the environment of a decision.

In the past it was assumed and unstated.

Stable context leads to predictable behavior and linear thinking.

What is an Expert in your Area?

1. *Someone that tells you the rules to make good decisions.*

2. *Someone that gives you good decisions, but the claimed rules for his decisions aren't useful.*

What is an Expert?

Someone that tells you rules or decisions?

- *Expert systems only work if the expert understands the system.*
- *Otherwise, "Co-Operational" approaches are the best way to predict the future.*

The human brain is a Co-Operational system

- *Process recognition versus pattern recognition.*

Sustainable strategies in fast changing times

- **Recognize stages** in organizations and groups
  - Match actions to stages
- **Active self-organizing processes**
  - Keep strategic plans simple (Eisenhardt)
  - Focus on process, not products
  - Socialize “world views” and common understanding
- **Enable and sustain diversity**
  - Best at recognizing the herd in action
  - Optimal for filtering and amplifying innovation
  - Diverse groups = diverse information
- **Improve your response to herd behavior**
  - The herd solution will not be robust or optimal
  - Recognize herding by loss of diversity and reduced social network
  - Enable diverse communities
- **Consider universal ethics vs. community (herd) ethics**

Where do you want to be?

Diversity is repressed by Exclusive Cooperation

Inflexible interactions – Fragile systems

Diversity leads to

Solution of hard problems by diverse individuals

Robust solutions

Diversity leads to Conflict and Competition

“Typical scientist … he never talked about emotions”

(for the next time)

Instructions for Life - Nobel Laureate *Tenzin Gyatso*

- **Take into account that great love and great achievements involve great risk.**
- When you lose, don't lose the lesson.
- **Follow the three R's: Respect for self, Respect for others and Responsibility for all your actions.**
- **Remember that not getting what you want is sometimes a wonderful stroke of luck.**
- **Learn the rules so you know how to break them properly.**
- Spend some time alone every day.
- **Open your arms to change, but don't let go of your values.**
- **Share your knowledge. It's a way to achieve immortality.**
- **Once a year, go someplace you've never been before.**
- Approach love and cooking with reckless abandon.

Norman L. Johnson
Los Alamos

http://ishi.lanl.gov